

TDM Pseudowire

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TDM PSEUDOWIRE



During the last decade, pseudowire technology has been established as the de-facto enabler for migrating legacy communications services to economical, higher bandwidth packet switched networks (PSNs). Today, TDM pseudowires are implemented in many mainstream services, transparently carrying voice, video and data traffic end-to-end over Ethernet, IP or MPLS backbones.

What are TDM pseudowires?

Pseudowire (PW) emulation is a method for transmitting any Layer 2 protocol over packet switched networks. It allows a seamless connection between two network elements by creating logical links, or virtual tunnels, across the packet network. In TDM pseudowires, the transmitted E1, T1, E3, or T3 streams are encapsulated in packets upon entering the network and then reconstructed at the pseudowire egress, where clocking information is also regenerated. As a result, real-time traffic is delivered transparently without distortion, avoiding the complexities of translating signaling data, while ensuring that synchronization criteria are met.

The pioneering author of various pseudowire RFCs, recommendations and implementation agreements, RAD has been actively involved in the creation of the industry's major pseudowire standards by the IETF, ITU, MFA, and MEF. Since first introducing TDMoIP pseudowire encapsulation to the market in 1999, RAD has deployed more than 60,000 pseudowire links worldwide. Our vast expertise and industry-leading know-how create field-proven solutions that ensure service continuity for TDM applications, with full support for legacy equipment, such as Class 4 and 5 switches, PBXs and TDM multiplexers.

RAD's TDM pseudowire expert solutions

RAD offers a diverse mix of TDM pseudowire access gateways – from small customer-located equipment, to high-capacity aggregation units for central offices or points-of-presence (POPs). The IPmux family of TDM pseudowire gateways (see pages 172-179) handles full E1/T1, fractional E1/T1 and E3/T3 streams right off the user premises, while the Gmux-2000 (pages 180-181) offers a modular chassis for aggregating and terminating pseudowire traffic. Together, they provide circuit extension over packet with VLAN-based service

differentiation, using any media, including fiber, copper, HFC, microwave, and satellite access. In addition, the TDM pseudowire access gateways incorporate dedicated ASICs featuring all standard TDM pseudowire modes, with end-to-end QoS and OAM attributes to meet service-specific performance criteria.

RAD also offers innovative TDM pseudowire gateways in an SFP (small form factor pluggable) format, maximizing user flexibility with a simple and cost-effective alternative to conversion cards. Designed for quick and simple insertion into any Fast Ethernet device port with a compatible SFP socket, the MiTOP-E1/T1 and MiTOP-E3/T3 simplify management and save on space, power consumption and cabling (see page 182).

Compelling benefits

RAD's TDM pseudowire access gateways offer a high degree of flexibility in determining the migration path to packet transport by allowing access agnostic delivery of all services and transmission protocols. Other benefits include:

- Enabling end-users to keep their existing equipment
- Eliminating the need to invest in separate, service-dedicated networks
- Supporting quick and non-disruptive upgrade of legacy services to future-ready networks
- Simplifying network management, maintenance and operations
- Allowing more users to be served by the same infrastructure

Who benefits from TDM pseudowires?

Incumbent carriers cut operating expenditures (OpEx) and minimize customer churn by converging legacy traffic with new revenue generators, such as E-Line and E-LAN services, over cost-effective PSNs.

Alternative service providers and cable operators with packet-based infrastructure grow their customer base by adding traditional leased line and private line services to their Layer 2 portfolio.

Enterprises reduce their IT expenses on PSTN connectivity and branch-to-branch communications by consolidating PBX, ISDN BRI, video, and data traffic over a single, economical Ethernet link.



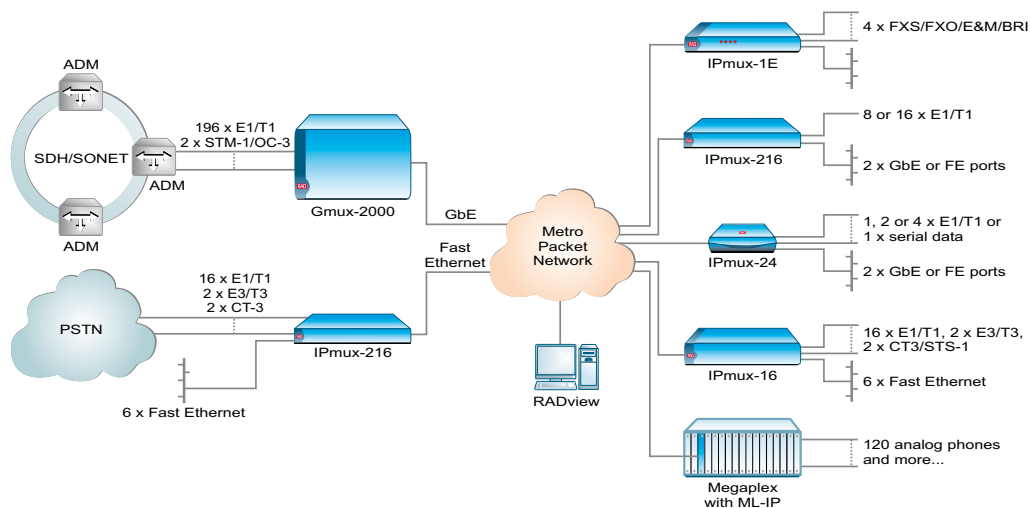
Mobile operators and transport providers reduce backhaul costs and ensure SLA enforcement for colocated towers and tower clusters over Fast/Gigabit Ethernet access rings.

Popular TDM pseudowire applications

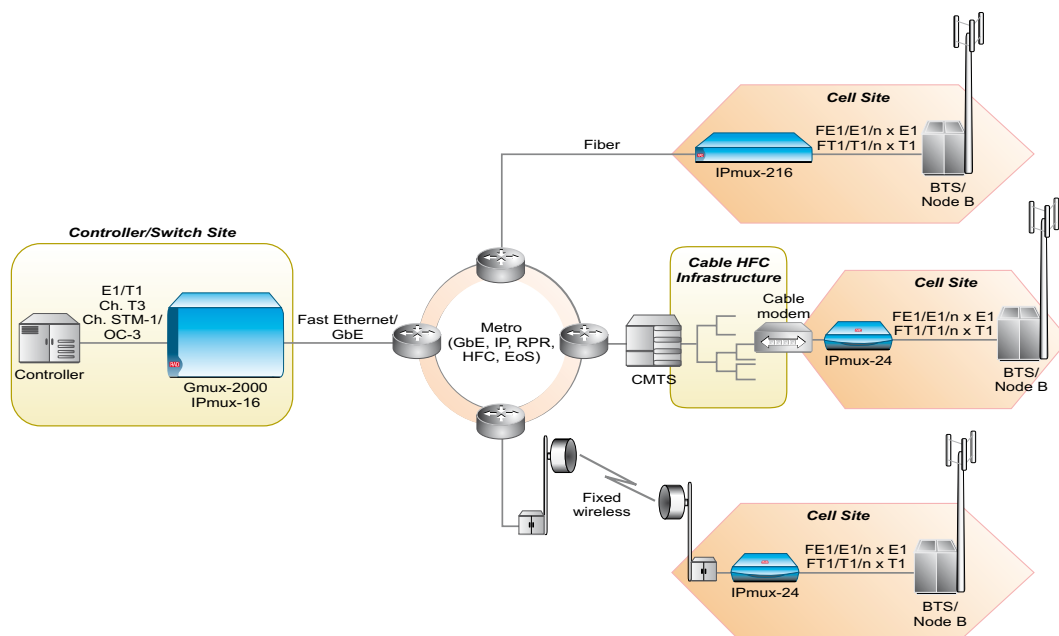
- Leased line services over Ethernet, IP or MPLS
- Service extension over packet access
- Private line and transparent LAN services (TLS) over Metro Ethernet
- Cellular backhaul over packet transport
- Leased line replacement with packet transport for enterprises

Synchronization and clock recovery

Because PSNs are inherently asynchronous, they introduce impairments, such as packet delay, delay variation and packet loss. RAD's TDM pseudowire gateways incorporate adaptive clock recovery (ACR) and synchronization schemes to overcome packet transport's inefficiencies and ensure end-to-end timing accuracy for real-time services. Complying with ITU-T G.823 and G.824 specifications, they facilitate multi-vendor interoperability and support ppb (parts per billion)-level frequency accuracy levels.



E1/T1, E3/T3 and Ethernet services over PSN



Cellular backhaul over PSN





IPmux-24

TDM Pseudowire Access Gateway

- Extends TDM, HDLC and Ethernet services over packet transport
- Up to four E1/T1 TDM user ports
- Three SFP-based fiber or copper Fast Ethernet or Gigabit Ethernet interfaces
- Multi-standard TDM pseudowire ASIC: TDMoIP, CESoPSN, SAToP, HDLCoPSN, CESoEth
- Ethernet ring support with 50 ms fail-over time
- High precision clock recovery for 2G/3G cellular traffic over PSN
- QoS per 802.1p, ToS/DSCP, EXP
- Ethernet link and TDM pseudowire redundancy
- MEF-9, MEF-14 certified for EPL services

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The IPmux-24 TDM pseudowire access gateway transparently delivers framed or unframed E1 or T1 signals, HDLC-based data streams, and user LAN traffic over packet switched networks, via copper or fiber Fast Ethernet or Gigabit Ethernet uplinks.

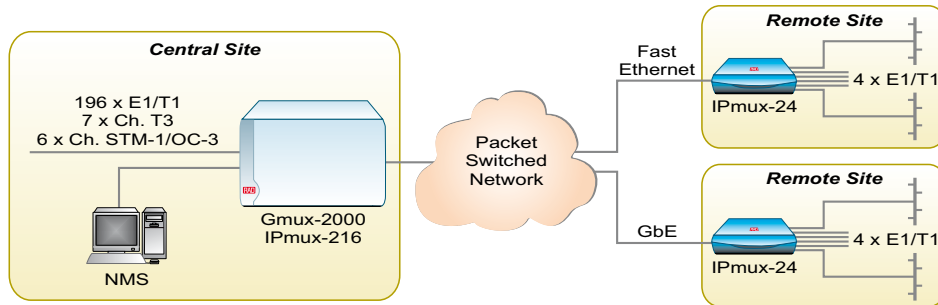
The IPmux-24's compact design, ease of installation, and advanced traffic management capabilities enable carriers to extend their services from legacy backbones over greenfield packet networks, without affecting customer experience or replacing existing end-user equipment. It also allows service providers to add traditional leased line services to their Layer 2 portfolio and permits enterprises to reduce their IT expenses on PSTN connectivity and branch-to-branch communications. In addition, it supports cellular operators in migrating their services to economical packet switched backhaul.

Advanced pseudowire functionality

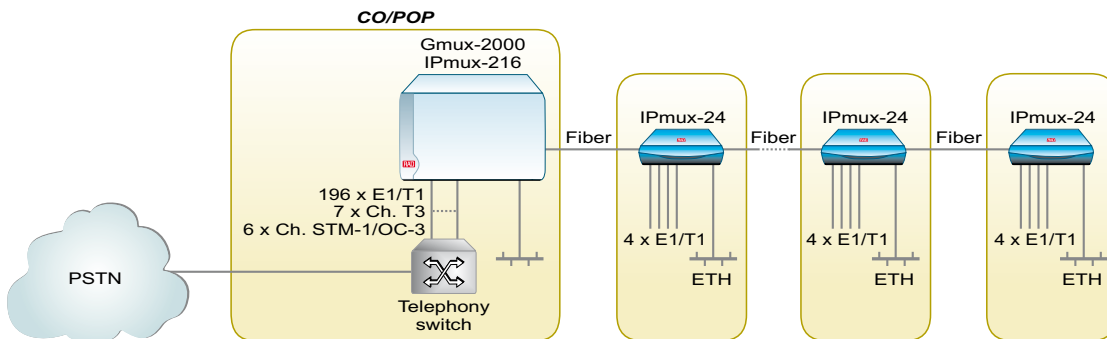
Incorporating RAD's new generation of ASIC processors, the IPmux-24 features enhanced pseudowire performance with minimal processing delay, including support for all standard TDM circuit emulation modes, such as TDMoIP, CESoPSN, SAToP, HDLCoPSN, and CESoEth (MEF-8). Featuring a 64-circuit pseudowire capacity, the IPmux-24 enables each timeslot to be assigned a separately configured pseudowire connection, thereby supporting multiple PW flavors simultaneously. By grooming DSO-level bundles, the IPmux-24 also facilitates an efficient use of the expensive TDM ports.

Clock recovery and timing

The IPmux-24 ensures end-to-end timing accuracy for real-time services across non-deterministic packet networks. Featuring adaptive clock recovery (ACR) capabilities per



E1/T1 extension over packet switched network



Daisy-chain application





port, a remote IPmux-24 can accurately regenerate an original clock transmission in varying network load conditions. The IPmux-24 conforms to ITU-T G.823/G.824 traffic and synchronization interface requirements and to G.8261-defined scenarios, providing low latency, attenuating delay variations and enabling service resiliency. Such high precision clocking attributes provide a frequency accuracy level of 16 ppb, guaranteeing a smooth operation of 2G and 3G cellular equipment over PSNs.

Ethernet QoS and VLAN capabilities

The IPmux-24 includes an internal Ethernet bridge, operating in either VLAN-aware or VLAN-unaware mode. It supports VLAN tagging per IEEE 802.1Q and VLAN stacking (Q-in-Q), which allow traffic separation between different users or services. Supporting Ethernet private line (EPL) service provisioning, the IPmux-24 also

includes enhanced traffic engineering and CIR/CBS rate limitation features, thereby enabling service providers to granularly adjust bandwidth to fit capacity requirements. SLA enforcement and QoS guarantees are supported by four strict priority queues, classified by VLAN tags, per port 802.1p bits, IP Precedence, or ToS/DSCP bits.

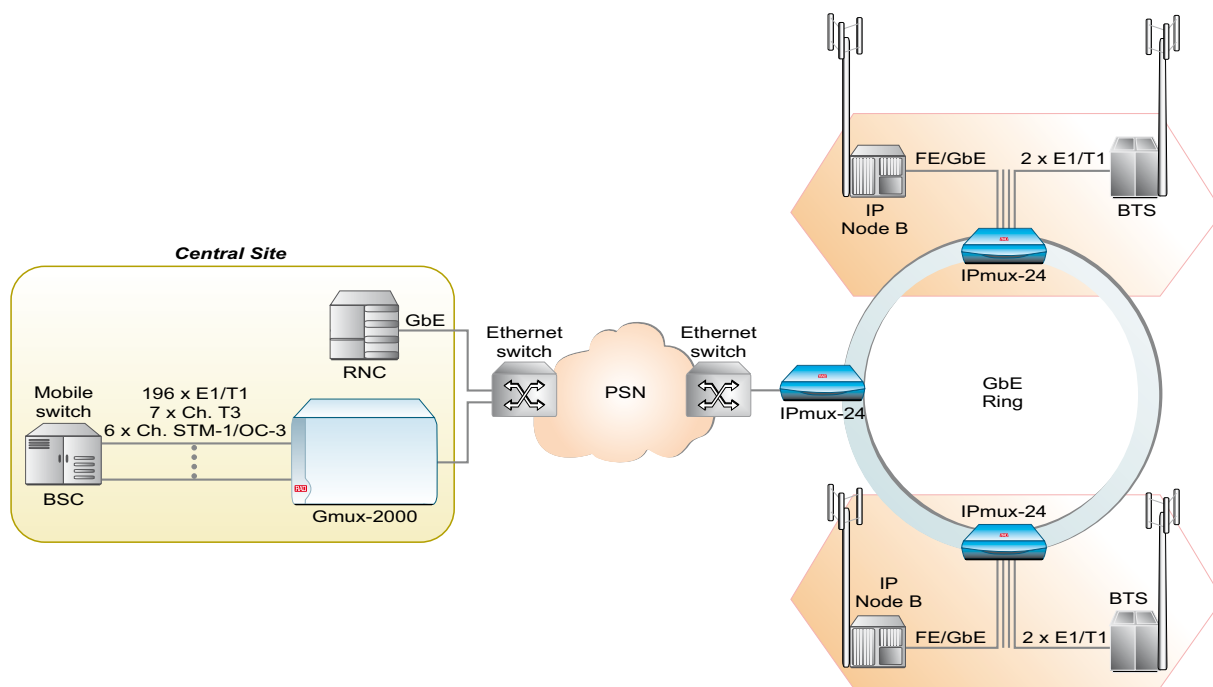
OAM and diagnostics

The IPmux-24 incorporates a pseudowire OAM mechanism that enables end-to-end monitoring of the pseudowire link, performing connectivity verification and round-trip delay measurements, as well as preventing pseudowire configuration errors. Diagnostic loopbacks can be remotely activated, while network condition statistics for the LAN and IP layers are also monitored and stored by the device. Performance monitoring parameters include packet loss, packet mismatch and packet delay variation.

Service center management and security

The IPmux-24 features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using the network or user ports, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security), service provisioning and diagnostic tools are provided by RADview-SC/TDMoIP, RAD's network management system, via an SNMP-based GUI.

The IPmux-24 also supports a variety of configuration access channels, including Telnet, SNMP, Web server, and TFTP. Incorporated security features include Secure Shell (SSH), Web-based Secure Socket Layer (SSL), SNMPv3, and RADIUS.



Cellular backhaul application over an Ethernet ring





IPmux-216

TDM Pseudowire Access Gateway

- Extends TDM, HDLC and Ethernet services over packet transport
- Eight or 16 E1/T1 TDM user ports
- Three SFP-based fiber or copper Fast Ethernet or Gigabit Ethernet interfaces
- Multi-standard TDM pseudowire ASIC: TDMoIP, CESoPSN, SAToP, HDLCoPSN, CESoEth
- Ethernet ring support with 50 ms switch-over time
- High precision clock recovery for 2G/3G cellular traffic over PSN
- QoS per 802.1p, ToS/DSCP, EXP
- Ethernet link and pseudowire redundancy

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The IPmux-216 TDM pseudowire access gateway transparently delivers framed or unframed E1 or T1 signals, HDLC-based data streams and user LAN traffic over packet switched networks, via copper or fiber Fast Ethernet or Gigabit Ethernet uplinks.

The IPmux-216's compact design, ease of installation and advanced traffic management capabilities enable carriers to extend their services from legacy backbones over greenfield packet networks, without affecting customer experience or replacing existing end-user equipment. It also allows service providers to add traditional leased line services to their Layer 2 portfolio and permits enterprises to reduce their IT expenses on PSTN connectivity and branch-to-branch

communications. In addition, it supports cellular operators in migrating their services to economical packet switched backhaul. IPmux-216's high port count makes it ideal for central POPs as well as for transport providers serving several mobile operators from shared towers.

Advanced pseudowire functionality

Incorporating RAD's new generation of ASIC processors, the IPmux-216 features enhanced pseudowire performance with minimal processing delay, including support for all standard TDM circuit emulation modes, such as TDMoIP, CESoPSN, SAToP, HDLCoPSN, and CESoEth (MEF-8). Featuring a 256-circuit pseudowire capacity, the IPmux-216 enables each timeslot to be assigned a separately configured pseudowire connection, thereby supporting multiple PW flavors simultaneously. By grooming DSO-level bundles, the IPmux-216 also facilitates an efficient use of the expensive TDM ports.

Clock recovery and timing

The IPmux-216 ensures end-to-end timing accuracy for real-time services across non-deterministic packet networks. Featuring adaptive clock recovery (ACR) capabilities, a remote IPmux-216 can accurately regenerate an original clock transmission in varying network load conditions. The IPmux-216 conforms to ITU-T G.823/G.824 traffic and synchronization interface requirements and to G.8261-defined scenarios, providing low latency, attenuating delay variations and enabling service resiliency. Such high precision clocking attributes provide a frequency accuracy level of 16 ppb, guaranteeing smooth operation of 2G and 3G cellular equipment over PSNs.

Ethernet QoS and VLAN capabilities

The IPmux-216 includes an internal Ethernet bridge, operating in either VLAN-aware or VLAN-unaware mode. VLAN stacking allows traffic separation between different users or services. Supporting Ethernet private line (EPL) service provisioning, the IPmux-216 also includes enhanced traffic engineering and CIR/CBS rate limitation features, thereby enabling service providers to granularly adjust bandwidth to fit capacity requirements. SLA enforcement and QoS guarantees are supported by four strict priority queues, classified by VLAN tags, per port 802.1p bits, IP Precedence, or ToS/DSCP bits.

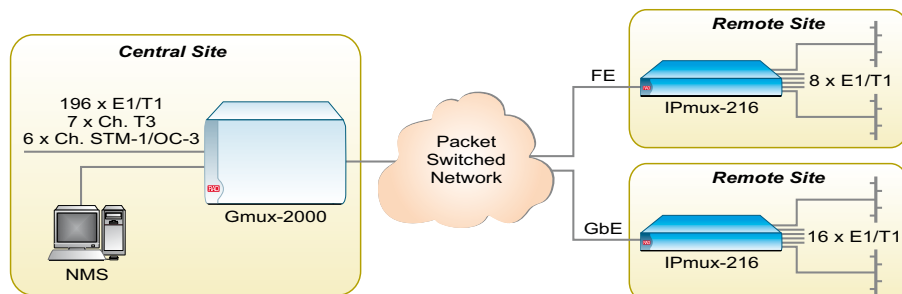
OAM and diagnostics

The IPmux-216 incorporates a pseudowire OAM mechanism that enables end-to-end monitoring of the pseudowire link, performing connectivity verification and round-trip delay measurements, as well as preventing pseudowire configuration errors. Diagnostic loopbacks can be remotely activated, while network condition statistics for the LAN and IP layers are also monitored and stored by the device. Performance monitoring parameters include packet loss, packet mismatch and packet delay variation.

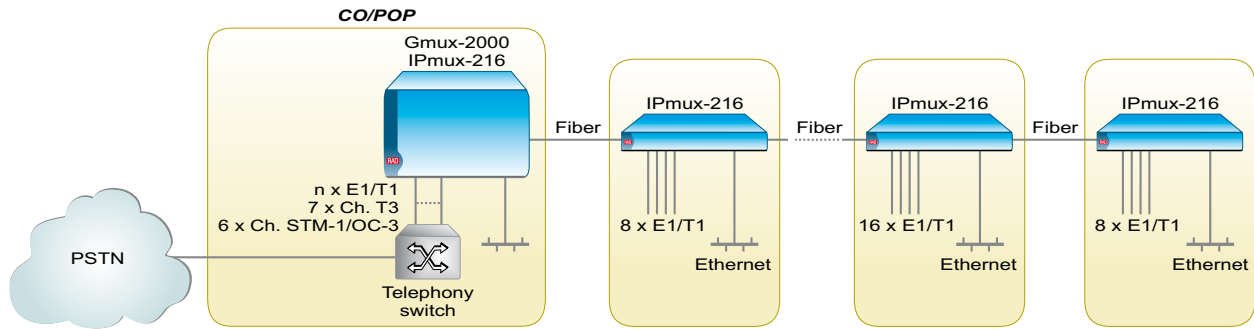
Service center management and security

The IPmux-216 features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using the network or user ports, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security), service provisioning and diagnostic tools are provided by RADview-SC/TDMoIP, RAD's network management system, via an SNMP-based GUI.

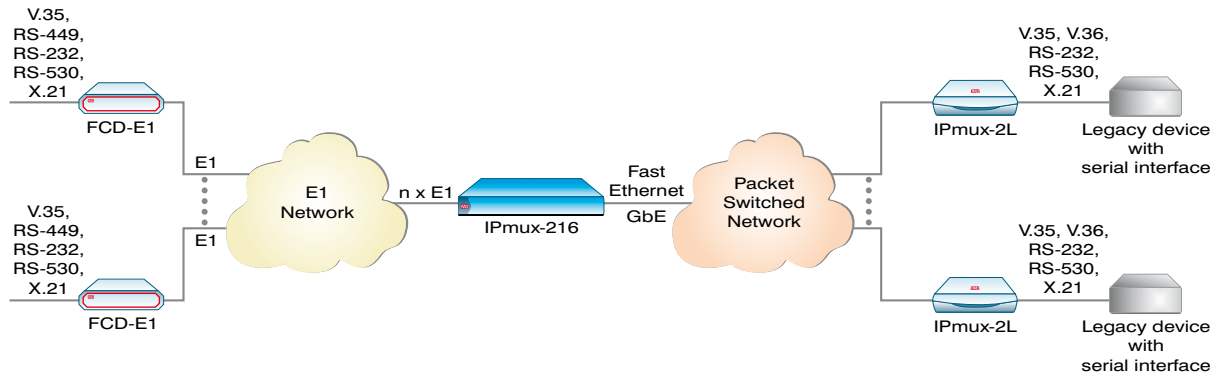
The IPmux-216 also supports a variety of configuration access channels, including Telnet, SNMP, Web server, and TFTP. Incorporated security features include Secure Shell (SSH), Web-based Secure Socket Layer (SSL), SNMPv3, and RADIUS.



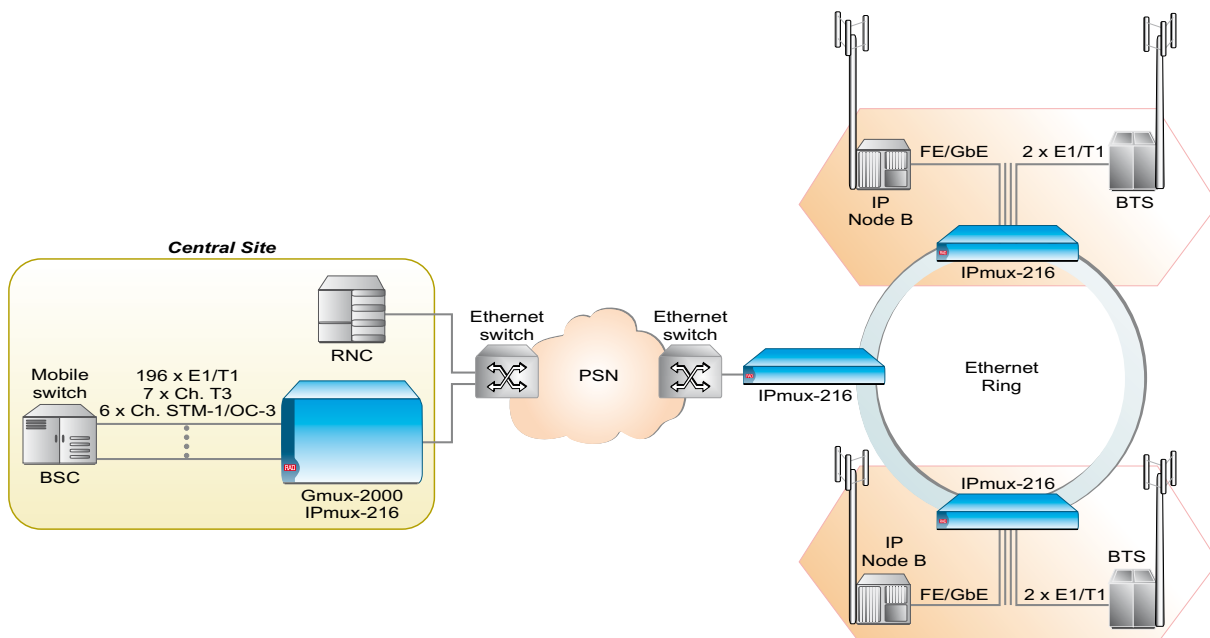
E1/T1 extension over packet switched network



Daisy-chain application



Serial data communications over a packet switched network



Cellular backhaul application over an Ethernet ring





IPmux-16

TDM Pseudowire Access Gateway

TDM-IP
Driven®

- Transmits TDM and LAN services over packet switched networks
- Modular design: E1/T1, channelized T3 and unframed E3/T3
- Cross connect between E1 and T1 ports
- Redundant fiber or copper Fast Ethernet uplink interfaces
- QoS per 802.1p, ToS/DSCP or EXP
- Advanced clock distribution over packet

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RAD's IPmux-16 TDM pseudowire access gateway is a modular carrier-class solution, using TDMoIP technology to deliver E1/T1, E3/T3 or channelized T3 services over IP, Ethernet and MPLS networks. Located at central service POPs, the IPmux-16 aggregates TDMoIP traffic from multiple sources.

The IPmux-16 employs standard pseudowire circuit emulation defined by the IETF PWE3, ITU-T and MFA Forum.

Integrated access

IPmux-16 enables economical transport of voice, video and data traffic over PSNs, supporting point-to-point and point-to-multipoint applications in carrier and enterprise environments.

Ethernet QoS and VLAN capabilities

User traffic can be rate-limited, tagged and filtered (based on VLAN classification), while double VLAN tagging (VLAN stacking) can be applied to better engineer the network. Outgoing frames are assigned Type of Service (ToS) or DiffServ values by the user, to allow higher priority forwarding for delay-sensitive traffic by Layer 3 routers and switches,

TDM circuit extension

IPmux-16 supports the following features:

- E1/T1 connectivity for any user device with standard E1/T1 interface
- Alarm detection and insertion with error statistics
- SES/UAS statistics, LOS/AIS physical layer alarms and remote/Local Loop test modes.

In addition, it supports standard E1/T1 alarms from end to end.

Modular design

The IPmux-16 is a modular, carrier-class TDMoIP gateway:

• E1 and T1 modules

The IPmux-16 supports up to two E1 or T1 modules that include four or eight ports each, for a maximum of 16 E1/T1 channels.

• Ethernet modules

IPmux-16 incorporates up to two Ethernet modules. Each module provides one or four Fast Ethernet ports with 10/100BaseT or up to two SFP-based ports. Redundancy and load sharing between the uplinks of the Ethernet modules are supported.

• E3 and T3 modules

Two unframed E3 or T3 modules can operate in a single IPmux-16 unit together with two Ethernet modules. When the hand-off interface required at the central site is T3, a channelized T3 module (see below) installed in the central IPmux can groom the unframed T1 links originating from multiple remote gateways.

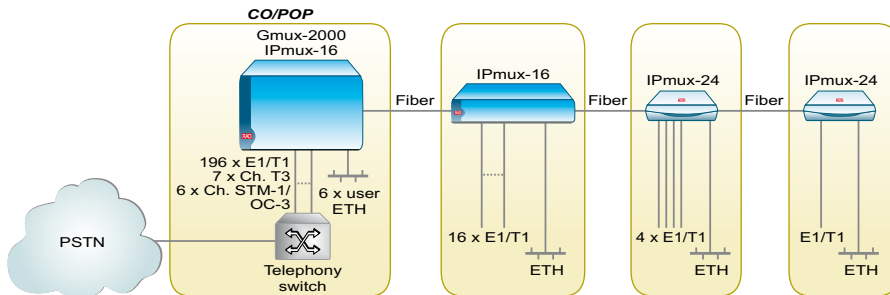
• Channelized T3 modules

These modules enable the IPmux-16 to function as a grooming device that can receive up to 28 T1 TDMoIP streams and groom them into channelized T3 at the central site.

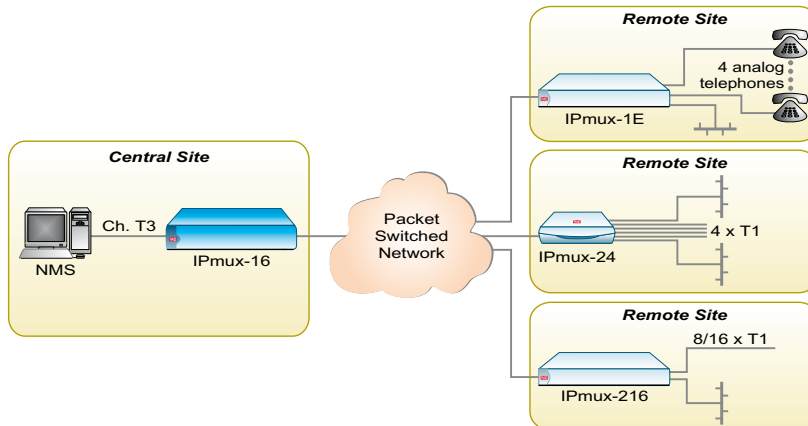
Service center management

The IPmux-16 features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using the network or user ports, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security), service provisioning and diagnostic tools are provided by RADview-SC/TDMoIP, RAD's network management system, via an SNMP-based GUI.

The IPmux-16 also supports a variety of configuration access channels, including Telnet, SNMP, Web server, and TFTP.



Daisy-chain application



T1 extension over packet switched network with T3 grooming at central site

IPmux-1E

TDM Pseudowire Access Gateway

TDM-IP
Driven®



Compact TDMoIP gateway for customer premises

RAD's IPmux-1E gateway reduces operating expenses by delivering virtually all TDM, data and LAN services over IP/Ethernet/MPLS networks, while ensuring strict priority for the TDMoIP traffic over the network link. End users continue to receive all familiar services, while carriers and service providers maintain revenues from legacy services. The compact size, ease of installation and support for multiple legacy and next-generation Ethernet and IP-based services make it ideal for small and medium-sized enterprises (SMEs).

Ethernet QoS capabilities

IPmux-1E answers the growing need of business customers for transparent LAN services, such as LAN-to-LAN interconnection and Ethernet connectivity to service providers. Enhanced QoS capabilities enable adaption of bandwidth to the transport media. Users can configure the ToS or DiffServ values of outgoing TDMoIP packets, to ensure they receive the required priority by network switches and routers. In addition, TDMoIP frames are assigned dedicated VLAN ID tags, to separate user and management traffic and to filter user traffic.

TDM circuit extension

The TDMoIP gateway can connect to any user device with a standard E1/T1 interface. It also offers connectivity for four ISDN BRI S0 channels or four analog voice channels, with optional near-end echo cancellation (up to a full E1/T1) for cases where a large end-to-end delay causes echoes, such as in satellite applications. This device supports alarm detection and insertion along with error statistics, SES/UAS statistics, LOS/AIS physical layer alarms, and remote/Local Loop tests. It supports standard E1/T1 alarms from end to end.

Interfaces

IPmux-1E is equipped with the following interfaces:

- TDM user port options:
 - Single standard E1/T1 port with echo canceller
 - Four analog (FXS/FXO/E&M) ports with optional echo canceller
 - Four ISDN BRI S0 ports
- One Ethernet uplink with 10/100BaseT or 100BaseFX interface
- Optional Ethernet user port with 10/100BaseT interface for LAN connectivity

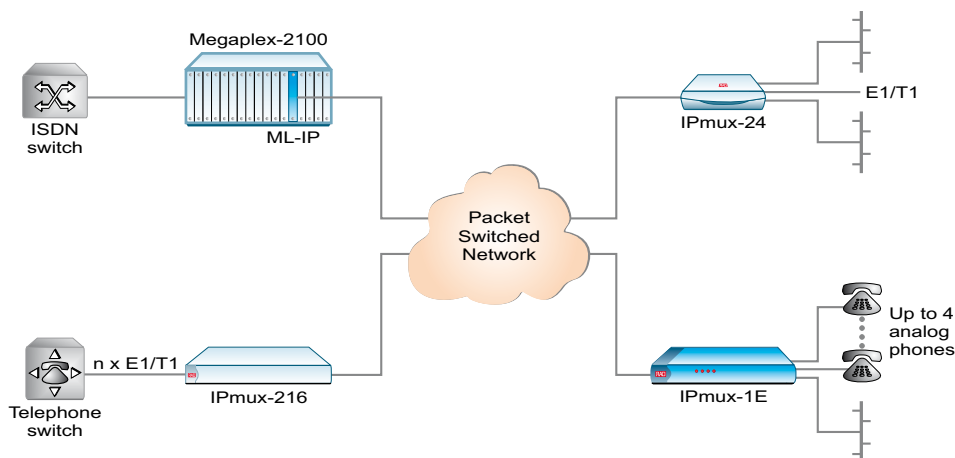
- Transmits TDM-based services over Ethernet, IP or MPLS networks
- Analog, ISDN BRI and E1/T1 user ports with echo cancellation
- Transparent LAN bridging over packet switched networks
- Fiber and copper Fast Ethernet uplink interfaces
- QoS support

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Service center management

The IPmux-1E features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using the network or user ports, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security), service provisioning and diagnostic tools are provided by RADview-SC/TDMoIP, RAD's network management system, via an SNMP-based GUI.

The IPmux-1E also supports a variety of configuration access channels, including Telnet, SNMP, Web server, and TFTP.



Analog extension over a packet switched network, grooming the traffic to n x E1/T1 at the central office





IPmux-2L

TDM Pseudowire Access Gateway

- **Delivers Ethernet and TDM-based services over packet switched networks**
- **One or two E1 user ports and a serial data port**
- **One SFP and two UTP Fast Ethernet ports**
- **Multi-standard TDM pseudowire ASIC: TDMoIP, CESoPSN, SAToP, HDLCoPSN**
- **QoS support with four priority queues**
- **Pseudowire OAM**
- **Per ITU-T G.823 jitter and wander performance**

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The IPmux-2L is a cost-competitive TDM pseudowire access gateway, converging framed or unframed E1 streams along with serial data and user LAN traffic over IP, MPLS or Ethernet networks. It offers an ideal solution for economical PSTN access and TDM trunking over wired and radio packet access. The IPmux-2L's extensive TDM pseudowire support enables enterprises and utility companies to take advantage of new packet switched networks for legacy services transport, without replacing their existing equipment or affecting service quality.

Advanced pseudowire functionality

Incorporating RAD's new generation of ASIC processors, the IPmux-2L features enhanced pseudowire performance with minimal processing delay, including support for all standard TDM circuit emulation modes: TDMoIP, CESoPSN, SAToP, and HDLCoPSN. Featuring a 63-circuit pseudowire capacity, the IPmux-2L supports individually configured pseudowire connections in timeslot granularity, thereby supporting multiple PW types simultaneously. By grooming DS0-level bundles, the IPmux-2L also facilitates an efficient use of the TDM ports.

Configurable packet size balances PSN throughput and delay while a jitter buffer compensates for packet delay variation (jitter) of up to 200 msec in the network.

Pseudowire timing

The IPmux-2L supports various clocking options to ensure synchronization as any standard TDM device. These include loopback timing, external clock source or internal, using the device's internal oscillator.

The IPmux-2L can also recover the original clock with great accuracy, using per-port adaptive clock recovery. It complies with G.823 traffic interface mask and provides frequency accuracy of up to 100 ppb (parts per billion).

Ethernet capabilities

The IPmux-2L includes an Ethernet switch featuring three Ethernet ports, whereby one port serves as the network interface and the other two are used for user traffic. Supported Ethernet attributes include port-based VLAN membership and VLAN tagging, as well as VLAN

stacking (Q-in-Q). In addition, it supports port-based rate limitation, enabling the total transmitted bandwidth to be adapted to the limitations of the transport media.

Ethernet QoS features include four priority queues, scheduled by Strict Priority or Weighted Fair Queue (WFQ). Traffic is classified according to IP Precedence, 802.1p, DSCP, or port default priority.

Interfaces

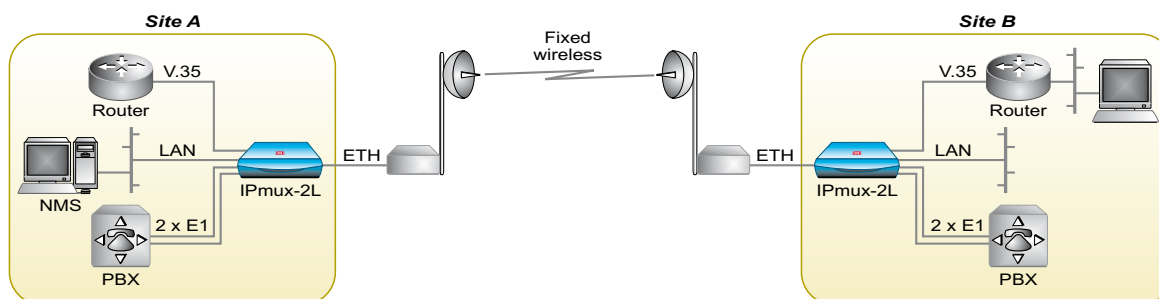
The IPmux-2L features the following interfaces:

- One or two E1 user ports
- n x 64 kbps port with various interface options: X.21, V.35, V.36/RS-449, RS-530/RS-422, and V.24/RS-232
- A single network Ethernet port, with an optional 10/100BaseT or 100BaseFX interface
- Two user Ethernet ports, both UTP-based, or one copper and one fiber-based

EMS management

The IPmux-2L features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using the network or user ports, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security) and diagnostic tools are provided by RADview-EMS, RAD's carrier-class element management system, via an SNMP-based GUI.

The IPmux-2L also supports a variety of configuration access channels, including Telnet, SNMP, Web server, and TFTP.



Multiservice connectivity over Ethernet fixed wireless using pseudowire

IPmux-155

Hub-Site Pseudowire Access Gateway



The IPmux-155 is a cost-competitive access aggregator, delivering TDM pseudowires and user LAN traffic to packet switched networks. In addition, it performs as a pseudowire termination unit, sending TDM bundles to SDH backbones and Ethernet traffic to packet networks.

Working opposite CPEs, such as the IPmux-2L, it allows enterprises to replace expensive leased lines with cost-effective packet transport and offers an ideal solution for economical PSTN access and PBX backhaul.

The IPmux-155 includes a wire-speed, non-blocking Ethernet switch. Its high capacity includes the following interfaces:

- 32 fiber or copper Fast Ethernet ports
- Four fiber or copper Gigabit Ethernet ports
- 1+1 STM-1 ports

Advanced pseudowire functionality

Incorporating RAD's new generation of ASIC processors, the IPmux-155 features enhanced pseudowire performance with minimal processing delay, including support for standard SAToP emulation mode. This allows the extension of TDM services from legacy backbones over greenfield packet networks without affecting service quality or user experience. The IPmux-155 supports separate configuration for up to 63 pseudowire connections. Configurable packet size balances PSN throughput and delay, while a jitter buffer compensates for packet delay variation (jitter) of up to 200 msec in the network.

Timing and synchronization

The IPmux-155 supports various clocking options to ensure synchronization as any standard TDM device. These include loopback timing, external clock source or internal clock, using the device's own oscillator.

The IPmux-155 can also recover the original clock with great accuracy, using adaptive clock recovery (ACR). In addition, clock capabilities include holdover and hitless switching.

Ethernet capabilities

The IPmux-155's Ethernet attributes include port-based VLAN membership and VLAN tagging, as well as VLAN stacking (Q-in-Q). In addition, it supports port-based rate limitation per granular committed information rate (CIR) and committed burst size (CBS), enabling the total transmitted bandwidth to be adapted to the limitations of the transport media.

Ethernet QoS features include four priority queues, scheduled by a Weighted Round Robin mechanism. Traffic is classified according to ToS/DiffServ, DSCP, 802.1p, or port default priority.

OAM and diagnostics

The IPmux-155 incorporates a pseudowire OAM mechanism that enables end-to-end monitoring of the pseudowire link. Diagnostic loopbacks can be activated, while network condition statistics for the LAN and IP layers are also monitored and stored by the device.

Performance monitoring parameters include packet loss, packet mismatch and packet delay variation.

EMS management

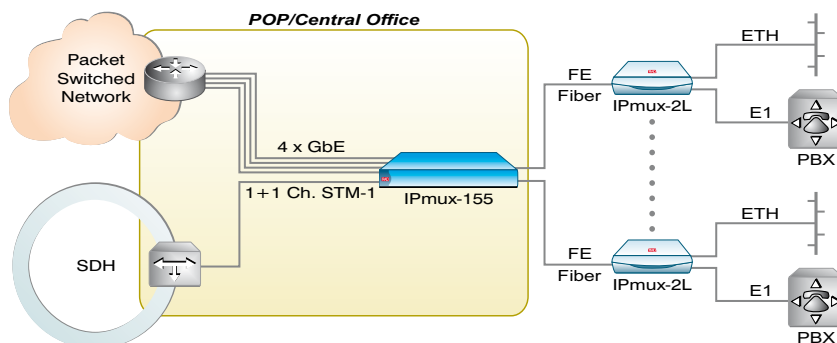
The IPmux-155 features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using the network or user ports, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security) and diagnostic tools are provided by RADview-EMS,

- Economical, high density gateway extending TDM-based services over packet networks
- Aggregates up to 32 customer-end gateways over Fast Ethernet links
- Provides PSN and SDH access over Gigabit Ethernet and channelized STM-1 uplinks
- ASIC-based, standard pseudowire support
- QoS with four priority queues
- Up to four GbE ports in link aggregation group according to 802.3ad; SDH APS (1+1) support
- Redundant power supply and fans

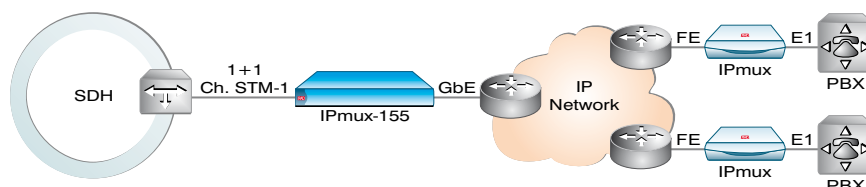
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RAD's carrier-class element management system, via an SNMP-based GUI.

The IPmux-155 also supports a variety of configuration access channels, including Telnet, SNMP, Web server, and TFTP.



IPmux backhaul aggregation and pseudowire termination for E1 and Ethernet traffic over fiber



Remote IPmux aggregation and pseudowire termination over PSN



Gmux-2000

Hub-Site Pseudowire Access Gateway

- High density gateway extending TDM-based services over packet switched networks
- Transports multiple E1/T1 links, channelized T3 or channelized STM-1/OC-3 over Gigabit Ethernet uplinks
- Multi-standard TDM pseudowire ASIC
- Fully redundant hardware, including all system and service modules
- QoS per 802.1p, ToS/DSCP or EXP
- VLAN tagging per 802.1Q, VLAN stacking (Q-in-Q)
- Ethernet OAM per 802.1ag and Y.1731

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The Gmux-2000 is a cost-effective, modular pseudowire access gateway with high capacity for extending TDM PDH and SDH/SONET services over IP, Ethernet and MPLS networks.

Incorporating TDMoIP, CESoPSN, SAToP, and CESoETH (MEF-8) pseudowire emulation standards from the IETF, MFA Forum, ITU-T, and MEF, the Gmux-2000 is an ideal solution for PSTN access, as well as for PBX and mobile backhaul. In addition, it enables transparent delivery of HDLC legacy traffic with HDLCoverPSN support.

The Gmux-2000 is available with a choice of interfaces, allowing it to relay, concentrate and groom up to 196 E1/T1, seven channelized T3 or six channelized STM-1/OC-3 links over two Gigabit Ethernet (GbE) network connections.

The Gmux-2000 works opposite RAD's IPmux TDM pseudowire gateways, LA-110 integrated access devices or Megaplex integrated access multiplexers, for cost-effective, carrier-class TDM pseudowire access.

Modules

The Gmux-2000 is a 6U-high chassis, mountable in a 19-inch ETSI or ANSI rack and houses the following modules:

- Up to two PSN network uplink modules
- Two control modules
- Three AC or DC power supply modules
- Seven I/O modules (E1/T1, Ch. T3 and Ch. STM-1/OC-3 interfaces)
- A cooling fans module

Gigabit Ethernet network modules, each with a pair of redundant Gigabit Ethernet (GbE) interfaces, support IEEE 802.3, 802.1Q (VLAN tagging), VLAN stacking (Q-in-Q) and 802.1p (priority/class of service).

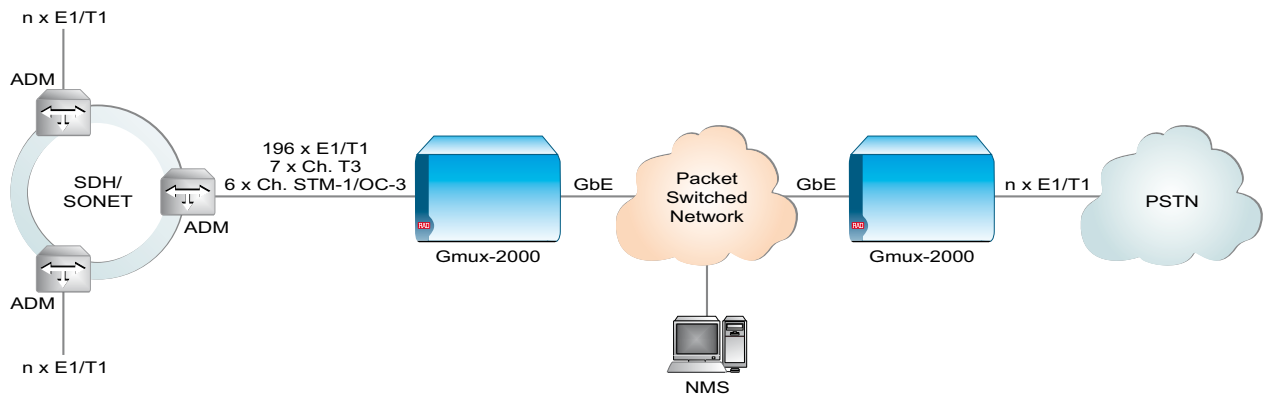
E1/T1 pseudowire (PW) modules encapsulate E1/T1 traffic flows for transmission over packet networks via the GbE network module. The E1/T1 modules include 28 external E1 or T1 interfaces for connecting individual E1/T1 ports.

STM-1/OC-3 PW modules perform SDH/SONET multiplexing/demultiplexing of channelized STM-1/OC-3 trunks into separate, internal E1/T1 circuits. Up to 63 E1 or 84 T1 internal channels are mapped into VC-12 or VT-1.5 streams to or from the channelized STM-1/OC-3 interface.

Each STM-1/OC-3 interface module provides a pair of ITU-T G.957 fiber optic links, supporting 1+1 redundancy according to ITU-T G.783.

Voice compression modules – Gmux-2000 supports up to seven voice compression modules compatible with the Vmux product line (see Gmux-2000 on page 155).

Control modules provide the SNMP and management interfaces, enabling the configuration and control of the entire Gmux-2000 system.



Extending multiple TDM trunks over a packet switched network



Each control module provides redundant interfaces for connecting external G.812 station clocks and for alarm inputs/outputs.

Power supplies are hot-swappable plug-in modules. Up to three AC or DC power supply modules can be installed for load-sharing and redundancy. Two modules are required to drive a fully equipped Gmux-2000 system.

Redundancy Options

The following redundancy options are supported:

- GbE port redundancy according to 802.3ad
- GbE dual homing port redundancy
- GbE module redundancy
- STM-1/OC-1 1+1 line redundancy between ports on the same module

- STM-1/OC-3 module redundancy
- 1+1 pseudowire redundancy
- n+1 redundancy for external VMX and E1/T1 pseudowire with NPS-101 modules

Service center management and security

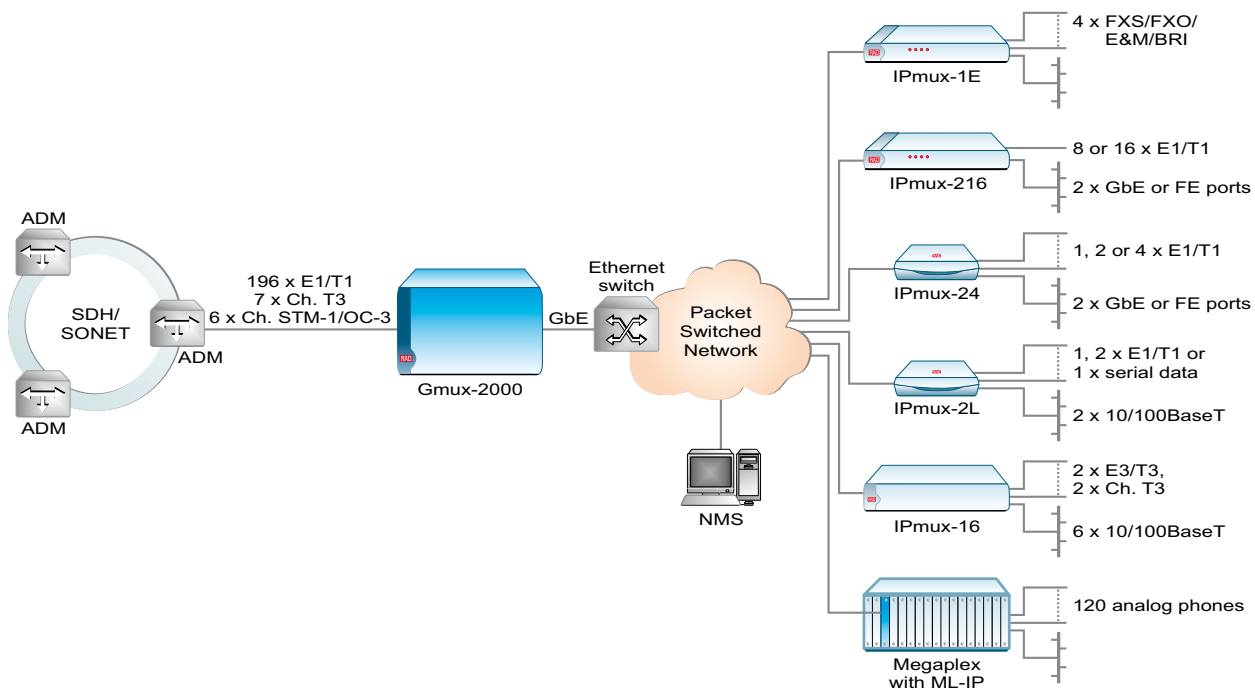
The Gmux-2000 features flexible management capabilities, including local management via an ASCII terminal (RS-232). In addition, remote management can be performed either inband or out-of-band, using one of the network ports or the dedicated management port, while maintaining separation between management and user traffic via the use of VLANs. Advanced FCAPS (Fault, Configuration, Accounting, Performance, Security), service provisioning and diagnostic tools are provided by

RADview-SC/TDMoIP, RAD's network management system, via an SNMP-based GUI.

The Gmux-2000 also supports a variety of configuration access channels, including CLI over Telnet, SNMP and TFTP. Incorporated security features include Secure Shell (SSH), Secure FTP (SFTP), SNMPv3 and RADIUS, as well as management access control list (ACL).

The Gmux-2000 incorporates Network Time Protocol version 3 for obtaining time of day information from the network.

It also supports Syslog, to enable system logs to be forwarded to an external network server, which is used as central repository.



Extending legacy TDM services over a packet switched network



MiTOP-E1/T1, MiTOP-E3/T3

SFP-Format TDM Pseudowire Gateways

System
on an **SFP**

- Transmit TDM-based services over Ethernet, IP or MPLS networks
- Standard encapsulation: CESoPSN, SAToP
- A single E1/T1 or E3/T3 TDM user port
- Transparent to all signaling protocols
- Hot-insertion SFP-format plug, MSA-compliant
- Selectable clock source
- Basic management of control, status and monitoring

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The innovative SFP-format MiTOP-E1/T1 and MiTOP-E3/T3 TDM pseudowire gateways provide PSN extension of E1/T1 or E3/T3 traffic. Housed in a small form factor pluggable (SFP) enclosure, the MiTOP TDM pseudowire gateways are designed for quick and simple insertion into any 100BaseFX Ethernet device port with a compatible SFP socket, making them ideal for providing transparent TDM circuit services over PSN.

Running on power derived from the host device, they require no additional power supply. They offer a simple and cost-effective alternative to external, standalone gateway units or conversion cards, as well as simplify management and save on space, power consumption and cabling.

The low-cost SFP plug format is an ideal and affordable solution for carriers and service providers delivering circuit extension over PSN, as well as for similar applications in enterprise and campus networks.

Pseudowire capabilities

Featuring ASIC-based architecture, the MiTOP-E1/T1 and MiTOP-E3/T3 incorporate multi-standard pseudowire support, including CESoPSN and SAToP. In addition, the devices

support MPLS, MEF-8 and UDP/IP network protocols.

The MiTOPs maintain large, configurable jitter buffers to compensate for delay variation introduced by the packet network.

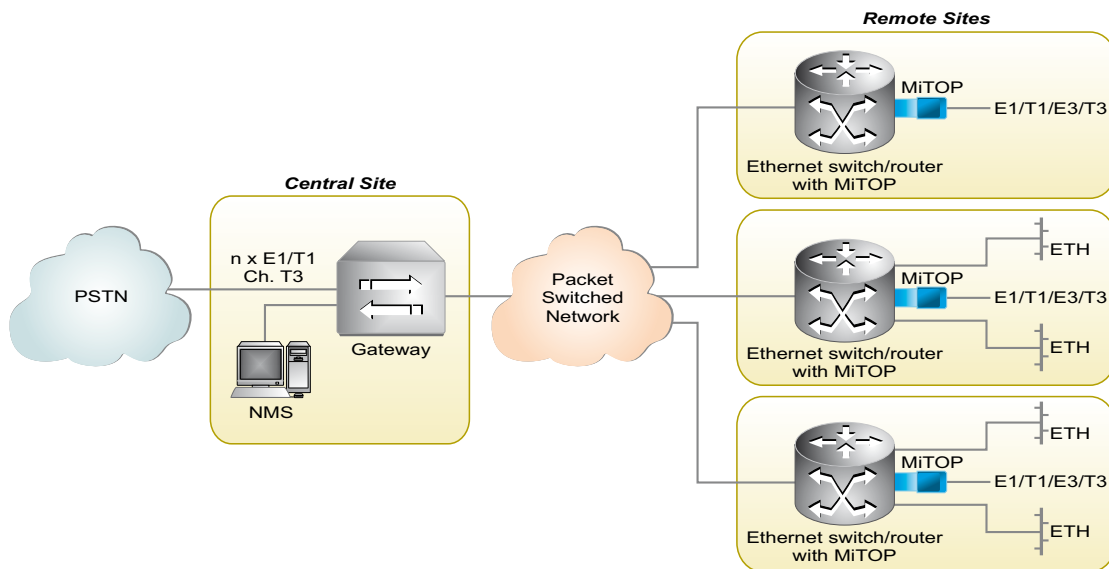
Four clock modes are supported: internal from a local oscillator; loopback timing clock recovered from the TDM network; adaptive clock recovered from the packet network; and external clock provided by a dedicated pin on the SFP edge connector.

The miniature gateways support multi-source agreement (MSA) product identification codes. They are hot-swappable and feature a special release mechanism for easy extraction from SFP sockets.

Management

The modules can be managed out-of-band via I²C and inband via dedicated Ethernet frames using a Web browser.

MiTOP can work opposite other MiTOP devices installed in remote equipment. Alternatively, they can work opposite gateways that support CESoPSN and SAToP, such as RAD's IPmux pseudowire gateways and Gmux-2000 central gateways.



E1/T1 extension over packet switched network